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National Foreign Assessment Center

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Use of Western Technology in the Ryad Computers of the USSR and Eastern Europe

An Intelligence Assessment

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June 1980

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National
Foreign
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Center

Secret [redacted]

Use of Western Technology in the Ryad Computers of the USSR and Eastern Europe (U)

An Intelligence Assessment

Information available as of 1 April 1980 has been used in the preparation of this report.

The authors of this report are [redacted] Office of Scientific and Weapons Research. The results of an independent contract with [redacted] also have been used in the preparation of this report. Comments and queries are welcome and may be directed to the Chief, Sciences and Technology Division, OSWR [redacted]

This report was coordinated with the Directorate of Operations and with the Offices of Economic Research, Strategic Research, and Research and Development. (U)

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Use of Western Technology in the Ryad Computers of the USSR and Eastern Europe [redacted] 25

Overview

Since 1969 the USSR and East European countries have been developing a family of general purpose computers known as the Ryad series. These computers essentially make up the total Soviet and East European effort in general purpose computers, and they have been and will continue to be used in a wide variety of civil and military applications. The architectural designs of the Ryad computers are patterned after those of the highly successful IBM 360 and 370 series of computers; the Ryad computers also use some Western engineering concepts in the implementation of IBM designs. [redacted] 25

Western technology has been important to the Ryad developments because it has provided proven design directions both at the system and component levels. Thus, Soviet and East European computer production efforts have been devoted to the most successful computer designs that have ever been mass produced, computers that could be used in a wide range of applications and could be highly serviceable in the field. With this approach the Soviets and East Europeans eliminated many of the risks in undertaking the development and production of a new series of general purpose computers, and in some cases they saved manpower and time. [redacted] 25

The Soviets and East Europeans have had varying success in assimilating Western developments in their Ryad systems. They have been successful in following Western design concepts and have applied some Western concepts within a few years after Western production models of computers used such designs. [redacted] 25

The Soviets have only been partially successful in the engineering implementation of their Ryad designs. Their success has been limited by shortcomings in their technical logistics supply and administration as well as in their supporting microelectronics base. In addition, the Soviets appear to have been misled in some cases by Western engineering designs that had not been fully proved for production process. The Soviets also have not been very successful in providing for the effective use of their Ryad systems; they have not yet duplicated Western successes in providing effective maintenance and software support to users. [redacted] 25

Soviet and East European development of the Ryad computer systems has been aided by virtually all available means for collecting technical know-how. Openly available and proprietary IBM technical information was of greater benefit to the Ryad developers, however, than were the acquisition and study of actual IBM hardware. [redacted] 25

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By patterning its most widely used general purpose computers after IBM designs, the Soviet Bloc will find itself committed to maintaining compatibility of its future general purpose computers with the IBM architecture it has adopted. While this may cause the Soviet systems to grow closer to IBM products in logical design and possibly engineering implementation, the time lag between the appearance of new IBM computer production and their Soviet and East European counterparts will increase. Thus, while they were approximately seven years behind the West in the mid-1970s in general purpose computer products, they will be using general purpose computers in the late 1980s that are comparable to Western models of the early 1970s. 25

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Use of Western Technology in the Ryad Computers of the USSR and Eastern Europe[redacted]

Introduction

For the past 10 years, the USSR and its East European allies have had a large cooperative project aimed at developing, producing, and using a compatible set of computing equipment for a wide range of general purpose needs. The status and trends in this family of computing equipment, which is called the Unified System (ES) or Ryad series, have been published in several previous studies.[1] This study will identify and evaluate specific uses of Western technology in the Ryad project, and only those Ryad computers that are known to have been patterned after and claimed to be compatible with the IBM System 360 and 370 models are discussed.[2][redacted]

The Ryad project was first announced in 1967 as a Soviet project. The undertaking, however, subsequently became an international venture in 1969 when Bulgaria, Czechoslovakia, East Germany, Hungary, and Poland joined the USSR to form the International Commission for Cooperation of the Socialist Countries in the Field of Computer Technology. Romania and Cuba joined the commission in 1973, and their contributions to the Ryad project are still minor[redacted]

Development Sequence

Development of at least some of the Ryad models must have been under way even before 1969 when the final decision apparently was made to follow the IBM pattern. This became apparent when prototypes of the first Ryad computers—now called the Ryad I models—were tested during 1971. Prior to 1969, the USSR and East Germany had employed IBM 360 logical architecture in their ASVT and R-21 computers, respectively, but they were unsuccessful because of the inadequacies of the component and circuit technology then available. Engineering differences in Ryad I computers from various development organizations also indicate that several local efforts to adapt IBM designs must have been under way by 1969. To support these efforts, the USSR and its allies used virtually all the collection means at their command to collect information on IBM 360 and 370 developments.[3][redacted]

A few interim or modified Ryad models were developed within three to four years after the first Ryad I models appeared. These interim models generally appear to have been intended to retain the same features of the Ryad I models and to upgrade their performance rather than to introduce features similar to the IBM 370[redacted]

The first prototypes of the Ryad II models were completed in 1976 and were oriented toward advancing the Ryad project to computers with features like those of the IBM 370. Selected operational characteristics of the Ryad I and II models are shown in the table[redacted]

Maximization of the range of computing applications that could be accommodated seems to have been a major goal in the selection of models for inclusion in the Ryad series. The Ryad developers largely avoided the inclusion of deviant models that have been offered in some Western families of computers in order to counter competition. Comparison of the data in the table with corresponding data on IBM 360 and 370 models reveals that no Ryad computer exactly replicates any specific IBM model in arithmetic and storage characteristics[redacted]

[1] *The Ryad Series of Computers*, SID-72-5, May 1972[redacted] *Soviet Ryad Computers: A Program in Trouble*, ER 77-10491, September 1977[redacted] *The Ryad II Series of Computers*, SI 78-10056, June 1978[redacted]

[2] Although the Hungarian ES-1010 and its derivative models are nominally included among the Ryad machines, they use designs licensed from France and are not compatible with the IBM 360 series. The Czechoslovak ES-1021 is not considered in detail as it does not implement the full IBM 360 instruction set. This study also does not focus on peripheral computer equipment, such as disk units or printers, as our intelligence on such devices is limited. In general, the design of such devices ranges from close physical duplication to indigenous designs that, in many cases, do not permit the ready interfacing of Western peripherals to Soviet or East European systems[redacted]

[3] For a general discussion of both overt and covert methods used by the USSR to acquire foreign technical information see *Mechanisms for Soviet Acquisition of US Technology*, SI 76-10028, November 1976[redacted]

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[redacted] 25

Selected Characteristics of Ryad Computers Similar to the IBM 360 and 370

	Ryad I Models					Modified Ryad I Models			Ryad II Models					
	1020	**1021**	**1030**	**1040**	**1050**	**1022**	**1032**	**1033**	**1025**	**1035**	**1045**	**1055**	**1060**	**1065**
Prototype date	1971	1972	1972	1972 [1]	1973	1975	1974	1975 [1]	1977 [1]	1976	1979	1978	1975 [1]	1980 [1]
Production date	1972	1974	1974 [1]	1974	1976 [1]	1976	1976 [1]	1976 [1]	1979	1978 [1]	1980 [1]	1979	1979	1982 [1]
Microprogram storage cycle (microseconds)	1.00	0.30	0.50	0.45	0.16	0.50	0.32	0.30	0.38	0.20	0.12	0.40	0.09	NA
Fixed point add time (microseconds)	20.1	23.0	8.1	1.50	0.64	2.9	2.10	1.50	5.0	4.5	0.7	0.6	0.25	0.12
Floating point add time (microseconds)	57.3	None	12.8	2.8	1.0	13.2	4.0	4.5	50.0	95.0	1.9	1.6	0.80	0.24
Floating point multiply time (microseconds)	411.0	None	31.9	6.0	1.8	33.9	13.1	8.5	9.7	19.8	2.8	2.7	2.3	0.30
Main storage capacity (K bytes) [2]	64 to 256	16 to 64	128 to 512	128 to 512	128 to 1,024	128 to 512	128 to 1,024	256 to 512	128 to 256	256 to 512	256 to 3,072	256 to 4,096	2,048 to 8,192	2,048 to 16,384
Bus width (bytes)	2	2	4	8	8	4	4	4	2	8	8 [1]	8	8	NA
Cycle time (microseconds)	1.5 to 2	2	1.25	1.35	1.25	2	1.2 to 1.3	1.25	0.625	2.0	1.0 to 1.2	1.2	1.65	NA

[1] Estimated

[2] Kbytes = 1,024 bytes.

[redacted] 25

External Appearance

In the Ryad series of computing equipment, Soviet and East European designers have tried—with mixed success—to duplicate the appearance and esthetic appeal, as well as the functional capabilities, of models widely used in the West since the mid-1960s. Ryad equipment cabinets are assembled from interchangeable metal parts rather than from the individually fitted parts that were used in earlier Soviet computer cabinets. Color schemes are similar to those used by IBM since about 1970, but, with the exception of the East German ES-1040 and ES-1055 models, finishes do not meet current or past Western standards. In general, the ES-1040 and ES-1055 models look more like IBM computers than the other Ryad models [redacted]

Soviet computers developed before the Ryad series traditionally had separate wood-topped operator consoles. The Ryad I models, however, have followed the IBM 360 approach used in approximately 1964 of having operator panels mounted directly on equipment cabinets. These panels are used by computer engineers responsible for maintenance and by computer operators. The arrangement of switches, keys, and lights bears a close similarity to those on IBM 360 computers with some of the switch settings locked out from operators. The operator panels of the ES-1040 and larger models have profiles similar to those adopted for the IBM models because of human engineering considerations (see figure 1). Operator panels with a vertical profile like that on the early Soviet ES-1020 and ES-1030 computers (see figure 2) were not used on IBM 360 models, but they were used on some earlier IBM computers. [redacted] 25 25

The East German Ryad II computer, the ES-1055, departs from the Ryad I computers in that it has a separate console for the operators and the computer engineer (see figure 3). The use of a separate console with a cathode-ray tube display is consistent with

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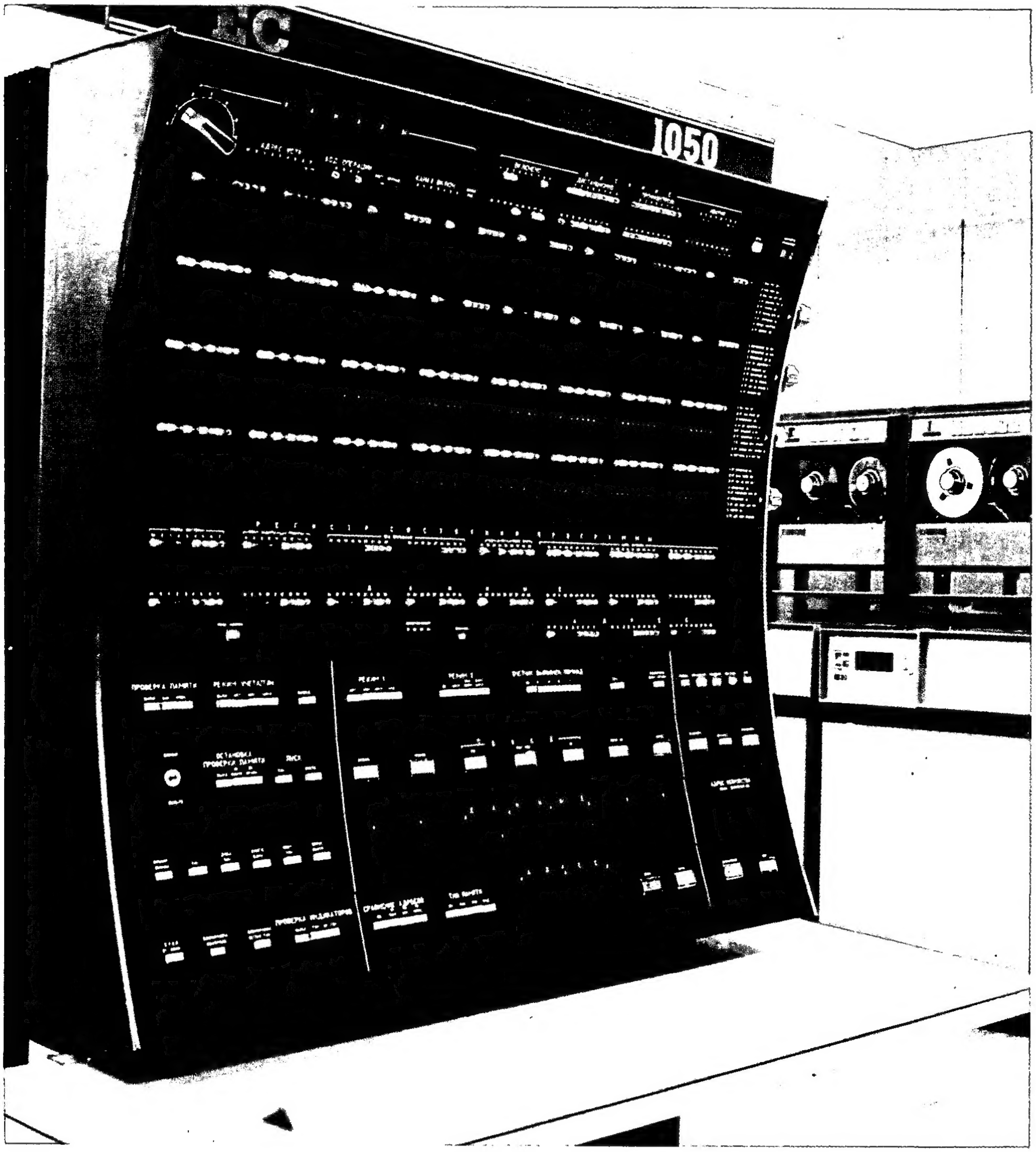
Control Panel of the ES-1050 Computer

Figure 1



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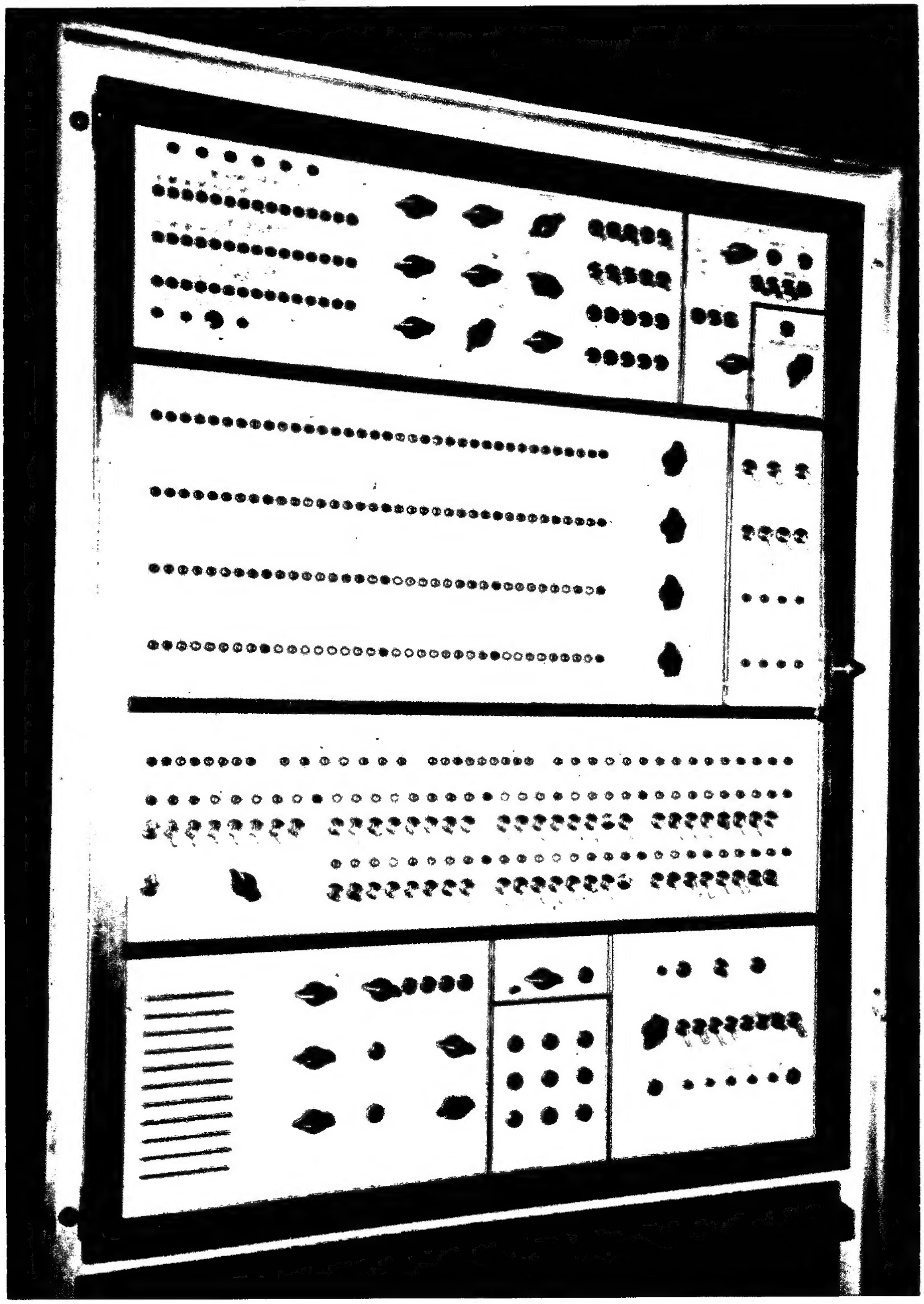
Control Panel of the ES-1030 Computer Figure 2



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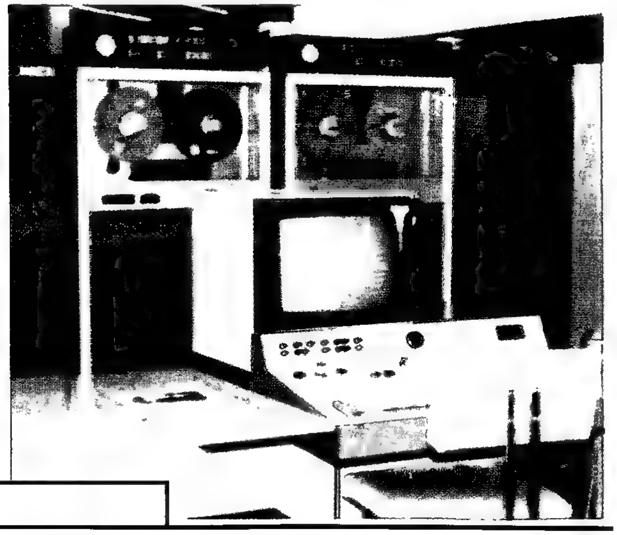
ES-1055 Computer at Leipzig Trade Fair, 1978 Figure 3



[redacted]

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IBM's practice in their 370/158 and other larger scale models of the early 1970s. The use of a cathode-ray tube display rather than registers and arrays of buttons and switches is highly desirable from an engineering viewpoint [redacted]

The Ryad computer designers also have followed the West in abandoning the concept of having a switch and light for every register in the computer. Maintenance procedures used with discrete component machines both in the West and in the USSR required such provisions for testing purposes. About the time the IBM 360 models were introduced, maintenance procedures utilized diagnostic programs in which the results were displayed by means of printers or cathode-ray tubes. [redacted]

Logical Architecture and Design

Ryad I Models. The Ryad I computers use the same basic logical architecture as the IBM 360 models that were first produced in the West in 1964-65. Of all alternative designs, the Soviets probably chose the IBM logical architecture because it is best suited to the Ryad goal of providing a compatible family of computers that can serve the needs of a wide range of general purpose applications. Obviously, an important factor in choosing the IBM 360 and 370 architecture was the availability of large amounts of software and design information. But, an even more important factor was the Soviets' desire to eliminate risks in making the decision. In addition to its proven successes in IBM products, the 360 architecture already had been adapted into successful products by some other Western computer manufacturers [redacted] 25

IBM 360 architectural features of the Ryad I computers include: an identical instruction set and data format, use of microprograms [4] to execute the instructions on variable length words expressed in increments of 8-bit bytes, an interleaved memory organization that permits overlapping of operations, look-ahead,[5] and instruction stacks.[6] None of these individual architectural features was unique to the IBM 360 computers, but IBM was the first to incorporate all of the cited features in one series of computers. For example, instruction stacks were available in some US computers in 1960-61, and interleaving without an instruction stack was in some US models in 1959. Also, 25 microprograming was first described by the British computer pioneer M. V. Wilkes in the early 1950s and was employed in a Soviet experimental computer that was described in 1961. [redacted] 25

The philosophy of the Ryad developers in respect to 25 faithfulness of duplication of IBM logical designs is difficult to pinpoint. The philosophy seems to have varied among the different design groups responsible for Ryad models. A comparison of Ryad microprogram cycle and arithmetic operational times with those of IBM models suggests that there are significant differences in the algorithms used for arithmetic. Faithful duplication of IBM algorithms is believed to have been attempted in the first Ryad models, such as the ES-1020, but probably failed because of differences in the circuit technology used. Generally, 25 some non-IBM developers in the West appear to have duplicated IBM logical designs more closely than the Ryad developers [redacted] 25

[4] In a microprogramed computer, execution of any instruction in the instruction list for that computer is accomplished by using a stored sequence of microinstructions or fundamental steps for automatically organizing and controlling registers, logic circuits, and data paths to carry out the desired operation. [redacted] 25

[5] Look-ahead is a feature that permits automatic examination of the programs and organization data storage to permit minimization of the time required for execution of the programs [redacted] 25

[6] An instruction stack is a feature for automatically organizing the storage and order of execution of the instructions in a program to achieve optimal use of a computer's memory, logic, and data transfer provisions. [redacted] 25

[redacted] 25

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[redacted]

The choice of microprograming for Ryads was an enlightened decision for the Council for Mutual Economic Assistance (CEMA) countries. Its use removes constraints on the variety of features that can be logically implemented by machine designers and permits intimate control of registers, logic, data paths, and variation in the sequence of steps and paths between arithmetic components. The selection of the sequence of steps and paths usually was hardwired in Western high-speed machines because the need to get control signals for paths and logic sequences from a memory resulted in time delays that could not be tolerated on such machines. Use of microprograming in large, fast Western machines only became practical about 1970-71 with the advent of IBMs 370/158, 370/165, and larger models. [redacted]

Although the Ryad I computers are believed to duplicate the IBM 360 models functionally, information is insufficient for a precise detailed comparison of Ryad I and IBM 360 logical design. The details of the logical designs of the Ryad computers probably are not congruent with those of any IBM 360 machines because of the apparent differences in algorithms. Additionally, the differences in the kinds of electronic components used by IBM and Ryad would negate any benefits from direct implementation of detailed logical designs from IBM. [redacted]

Unsuccessful Hungarian attempts to execute an IBM 360 program on an ES-1020 also indicate that the duplication of IBM logical designs is not complete. Neither the ES-1020 nor ES-1030 models, however, appear to incorporate any architectural features not available in the IBM 360/30 and 360/40 models. [redacted]

The East German ES-1040 appears to have the most balanced logical design of the Ryad I computers. On one hand, its design appears conservative in that it duplicates the IBM 360 more closely than other Ryad I models. An unmodified IBM operating system was loaded into an ES-1040, and it executed applications programs without any problems. On the other hand, the ES-1040 displays an aggressive design approach in that it has an instruction logic that does not appear to have been taken from any Western machine of comparable speed and capabilities. The ES-1040 has memory interleaving, instruction look-ahead, and an instruction stack for three 64-bit words that permits queuing of up to six instructions. No IBM model had all of these features in a single model. For example, the IBM 360/50 in 1965 had the look-ahead feature but not the instruction stack. [redacted]

The ES-1050 is not microprogramed in the strictest sense. Unlike the ES-1020, ES-1030, and ES-1040, which use read-only memories to store microprograms, the algorithms for arithmetic and control are hardwired in the ES-1050. In this respect, the ES-1050 follows the practice used by IBM in its large, high-speed models such as the IBM 360/75 model in 1966-67. It is not known if the ES-1050 copied the IBM approach through desire or necessity. In either case, the Soviets probably chose hardwiring to obtain speed advantages reflected in other component and design features [redacted] 25X1

Interim Ryad Models. The logical architectural and design features of the ES-1022 and ES-1032 computers appear little changed over those of their predecessors, the ES-1020 and ES-1030, respectively. The ES-1032 appears to have been produced only in Poland, although Soviet specialists may have participated in its development. The main thrust in the development of the ES-1022 and ES-1032 apparently was to correct mistakes made in the development of their predecessor models. [redacted] 25X1

Another interim Ryad computer, the ES-1033, appears to have been an ambitious effort that was influenced by Western developments of the late 1960s. The ES-1033 design appears to be new rather than a simple extrapolation of that of the ES-1030, which was done at Yerevan. The ES-1033 design may have been a result of the transfer of the ES-1030 production and presumably follow-on design responsibilities from the Yerevan Computer Plant to the Kazan Computer Plant. The Kazan plant, which developed the ES-1033, has displayed better engineering capabilities than the Yerevan facility [redacted] 25X1

The ES-1033 has the same number of instructions as its predecessor but incorporates faster algorithms in most of its instructions. It also is claimed to have error-recovery aids and microdiagnostics, implying the use of a relatively large microprogram store. Microdiagnostics are not mentioned as a part of any Ryad models before the ES-1033 [redacted] 25X1

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The ES-1033 reportedly has multiplexer channels that can be controlled by microprograms. This type of channel control was not used extensively in the West until the IBM 370s appeared in 1970-71. Previously, multiplexer channels were used only on very large machines and were hardwired. In recent Western computers, multiplexer channels are managed by an input/output director, which is a small computer operating under microprogram control; the director provides flexibility and enables many functions not practical in a hardwired design. Provision of a sufficient microprogram memory capacity, however, may increase the cost. The ES-1033 microprogram store is claimed to have a 300-nanosecond cycle time, which is probably faster than is needed for a computer in its class. [redacted]

The ES-1033 uses a trunk or bus organization [7] in its central processor; previous Ryad models did not utilize this design. The Soviets appeared to have used this approach in the ES-1033 in 1974-75, only a couple of years after Western manufacturers used it in the design of small- to medium-scale mainframes that were plug compatible with IBM computers. Both the USSR in the early 1970s and the West in the mid-1960s had used bus organizations for minicomputers. Use of a bus design generally reduces module interconnection requirements. This concept was developed for computers in which a single circuit board accommodates a complete computing function; the functions provided can be changed without changing backpanel wiring. [redacted]

Ryad II Models. It appears that the Ryad II models will attempt to incorporate all the features of the IBM 370 models. These include: virtual memory,[8] block multiplexers, an expanded instruction set, file protection, improved error handling, clocks for timing computer functions, and clocks for posting date and time of day. [redacted]

[7] Trunk or bus organization is an architecture that permits the instruction units, arithmetic units, and memory to share the same communications channel and communicate by time slots. [redacted]

[8] Virtual memory permits a programer to use a memory space with greater capacity than the main internal memory with only a small compromise in access time, that is, information in auxiliary storage can be addressed as if it were in main storage. [redacted]

Virtual memory probably is the most important and most distinguishing feature that the Ryad II series adopted from IBM. Virtual memory capabilities were included in computers that predated the 370 machines, but IBM named and popularized the concept and succeeded in making programers use it. As introduced by IBM, virtual memory is a combination of some fairly sophisticated hardware and software that provides a large amount of directly addressable memory. The hardware includes advanced disc drives (auxiliary storage) with high data transfer rates, new block multiplexers, special high-speed memories for addressing in some models, and new operating system software. [redacted] 25X1

25X1

The East German ES-1055 probably will be the first Ryad II model to implement all the hardware and design features needed for virtual memory. The other Ryad II models displayed in 1979 claimed to have these features, but it is doubtful that all of the features will be fully implemented in any Ryad II computers before mid-1980. The Soviets or East Germans could have implemented virtual memory on their Ryad I or interim Ryad models. The implementation, however, would not have been the same as that of the IBM 370 models, and such Soviet models would not have been able to execute IBM operating system software. [redacted] 25X1

The fact that the Ryad developers elected to introduce virtual memory in the same fashion as IBM is an indication that they intend to duplicate IBM models more closely in the Ryad II than they have in the Ryad I developments. There are no indications that efforts in this direction will diminish, in fact, they probably will increase. [redacted] 25X1

25X1

The Ryad computers that have been produced or announced will dominate the Soviet general purpose computing arena past the mid-1980s. The Soviets have a very large investment in developing, producing, and establishing the use of their Ryad computer hardware and software. This investment, including specialized training, will have to be amortized over some period of time, probably about seven years—as is the case in the West. Production of the Ryad II computers is just being established, and benefits from the attendant investments remain to be realized. [redacted]

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Engineering and Circuit Implementation

Ryad I Models. Western technology acquired both overtly and covertly by the Communist countries over the past 15 to 20 years as a part of their overall electronic industry buildup clearly has been a major asset in their ability to build the Ryad computers. Nevertheless, the selection of components and circuits for the Ryad computers to date was influenced more by local experiences and technical supplies than by Western technology acquired specifically for Ryad projects. [redacted]

The USSR apparently is just beginning to employ materials and practices used in the West since the early 1960s to reduce fire and safety hazards in computer installations. Fire reportedly has been a problem at Soviet ES-1020 and ES-1022 installations, and materials used for circuit boards may have contributed to these fire problems. Although the Soviets may be attempting to correct these problems by importing large quantities of Western equipment suitable for making boards of the types used in their Ryad computers, material standards similar to those used in the West to control fire hazards may not yet be implemented. Also, the provisions for power cabling and environmental control at Ryad installations are not up to the standards of IBM 360 installations. [redacted]

In place of the hybrid circuits used in corresponding IBM 360 models, the Ryad computers use monolithic integrated circuits (ICs). The ES-1020 and ES-1030 computers, for example, use two-sided printed circuit boards that mount up to 24 transistor-transistor logic (TTL) ICs per board. The use of TTL ICs in Ryad computers follows the pattern of non-IBM Western companies that developed computers on the basis of the IBM 360 architecture during the mid-1960s. The Soviet TTL circuits in Ryad are of the so-called "Logika 2" or 155 series. Nominally they have the same performance characteristics and are pin-for-pin compatible with the 7400 series of ICs first offered by Texas Instruments (TI) in 1961-62 [redacted]

The Soviets apparently attempted to reproduce faithfully the TI 7400 circuit designs but encountered production problems that resulted in design modifications. Circuit schematics for the 155 series ICs originally included in descriptions of the ES-1020 and ES-1030 computers were identical to the schematics for corresponding members of the TI 7400 series (figures 4a and 4b). Later Soviet 155 series ICs (figure 4d) used in these computers included an additional transistor to prevent saturation [9] and to obtain comparable operating speeds with the basic TI circuits (figure 4a). In contrast, modern US TTL ICs also use a gold doping process to overcome saturation problems. This process requires masking and diffusion techniques that permit the gold doping to be done to the part of the chip where it is needed and not elsewhere on the chip. 25X1
High-speed versions of the TI 7400 series (figure 4c) also include an extra transistor, but such circuits operate at almost twice the speed of the basic circuits. [redacted] 25X1

The Soviet choice for the circuit configuration in the TTL circuits may have resulted from the state of their technology, which was not as advanced as that of the United States, or from their adaptation of some past Western TTL IC designs. As diffusion and masking techniques were developing, there was a time when at least one US competitor (possibly the Suhl family of circuits from Sylvania) used a configuration similar to that shown on the Soviet TTL schematics in figure 4d. The configuration used in current Soviet production 155 series TTLs suggests that the available level of masking and diffusion technology is similar to that of the United States five to seven years ago. A tremendous change has occurred in Western processing technology over the period of TTL progress. [redacted] 25X1 25X1

Differences in the circuit technology used in storage units of the ES-1020 and ES-1030 models probably are largely attributable to the differences in experiences and in the kinds of technology readily available to the developers. Both ES-1020 and ES-1030 computers use ferrite-cores for the main internal store; the ES-1020 uses diodes in the protection key storage, and the ES-1030 uses plated wire. Plated wire probably was selected because of the experience gained at Yerevan

[9] As figure 4 illustrates, TTL 7400 series circuit is a combination of a multiemitter transistor on the input end of the chip followed basically by an amplifier and a push-pull output. The lower transistor of the push-pull output is prone to saturation and, once in saturation, turn-off is slow. [redacted] 25X1 25X1

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in the development of Nairi computers. The Soviets appear to have had trouble, however, in producing plated-wire memories [redacted]

Differences in the ES-1020 and ES-1030 circuit technology also are reflected in the microprogram stores. The ES-1020 uses closed-flux transformer cores in the read-only microprogram store, but the ES-1030 uses open-flux transformer cores. Western manufacturers have used both types of cores since the mid-1960s. The Soviets again appear to have incorporated components which they were capable of manufacturing and with which they were familiar. The Bulgarians, on the other hand, solicited the West for some of the components for the microprogram store in their version of the ES-1020 [redacted]

The ES-1040 reflects the application of East German engineering skills and experiences with high-quality fabrication techniques accumulated from past computer developments. Visual examination of the ES-1040 circuit board reveals a high level of capabilities near those of the West. The East Germans, no doubt, have taken advantage of their access to Western technology, particularly in West Germany. The ES-1040 circuit board, however, does not appear to be copied from any Western board. It is possible that the East Germans have assisted or are assisting the Soviets in making circuit boards for the ES-1050 and higher-performance computers [redacted]

The circuit boards used in the ES-1040 can accommodate up to 72 ICs, a density greater than that commonly found in US computers but the same as that used on the Soviet ES-1050. The use of such high-density board on the ES-1040 is surprising because Soviet literature on the Ryad project indicates that boards designed for 72 integrated circuits were intended for emitter-coupled logic (ECL) not TTL. Soviet descriptions indicate that boards for TTL will have less than 50 components. Such high densities for the ES-1040 boards would make them expensive to build and would cause yield problems [redacted]

One particular East German ES-1040 board that has been examined has approximately 68 ICs mounted on it and appears to be a multilayer type (six layers). 25X1
Etched-line widths on the board are approximately 25X1
10 mils (254 micrometers), which is considered good in current Western practice. The ES-1040 board uses approximately .3 of a square inch per integrated circuit, very dense by Western standards. This density is not required in the ES-1040, and the decision to use such a dense board may reflect a desire for engineering elegance that resulted in overengineering. The board is impressive from the standpoint of engineering design and craftsmanship [redacted] 25X1

The ES-1040 board might be intended for use in computers employing ECL circuits such as the ES-1050 and ES-1060 computers. Because the board has low impedance (on the order of 100 ohms), it might 25X1
be better suited for ECL circuit applications rather 25X1
than for the TTL circuits with which it is used. Apparently the ES-1040 designers were willing to take 25X1
some loss of speed to overcome noise problems [redacted] 25X1

The ES-1040 board uses a very good connector of remarkably high craftsmanship that is competitive with some of the best quality US types, but the connector does not appear to be a direct duplication of any US types. The connector is a high-density design that has pick-ups mounted so that a ground is provided as soon as the board is pressed into a connector and before power is connected. The provision for contacting ground before power is a feature found in some IBM equipment and in some US military equipment. The ES-1040 connector has two guide pins, and the ground pins are positioned along the connector strip so that 25X1
ground contacts occur even if the board is cocked during insertion. The connectors also use internal slotting with a cross-shaped cross section on the pins. [redacted] 25X1
25X1
The East German connector could be used on boards for ECL circuits that require very good grounding. Many failures occurred in the United States in moving from TTL to ECL technology because of inadequate grounding [redacted] 25X1
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In terms of overall speed, the ES-1040 is somewhat faster than its approximate counterpart, the IBM 360/50, which was a troublesome machine in part because of the total number of TTL circuits used and associated cross-talk problems. The ES-1040 seems to have managed these problems better, possibly because during the time interval between the IBM 360/50 and ES-1040, TTL technology matured. Also, the ES-1040 uses monolithic ICs instead of hybrids such as those used in the IBM 360/50. The TTL ICs on the ES-1040 circuit board appear to be of both Soviet and East German origin. Practically all the parts of the ES-1040 are of Soviet and East German manufacture, although a few US sense amplifiers were used in the main memory of other ES-1040s [redacted]

The back panel wiring of the ES-1040 uses a multilayer board (seven layers) with manual wire wraps, representing an aggressive approach. The early IBM 360 models had a two-layer back panel with wire wrap. IBM did not use multilayer back panels until the later 360s were made. [redacted]

The circuitry and component design features of the ES-1050 make it one of the most radical departures from the IBM 360 class of machines. The Soviets did not follow proven Western approaches and appear to have made serious design and engineering mistakes. One of the most striking features of the ES-1050 is that it is based on ECL monolithic integrated circuits. Although these circuits are capable of very fast operation, the ES-1050 is much slower than any US computer that has been built with ECL circuits. The use of ECL for the ES-1050 can be considered a conservative choice. When the ES-1050 was developed, the Soviets probably lacked sufficient control over the manufacturing processes to make TTL circuits that could be driven at the speeds required by the ES-1050. [redacted]

Comparison of the speed and the ES-1050 to its closest counterpart in the IBM 360 line, the Model 65, illustrates this point. The Model 65 was built on conventional TTL technology that probably resulted from unique production capabilities of IBM which the Soviets may not have been able to duplicate. The selection of ECL for the ES-1050 may have been the only practical choice for the Soviets, but the ECL circuits ran extremely hot and created heat dissipation problems. The severity of these problems probably is reflected in the long development time for the ES-1050 and the fact that some ES-1050s reportedly have remained barely operational or totally inoperative for long periods after installation. [redacted] 25X1

The design of the Soviet ES-1050 circuit boards probably was influenced by the vast amount of Western literature extolling the potential advantages of multilayer printed circuit boards. The ES-1050 uses 12-layer circuit boards, which represent a very aggressive design approach. US designers typically do not use 25X1 more than four layers on boards for mounting as many 25X1 ECL components as are on the ES-1050 boards. The Soviets may not have recognized the decline in the US developers' enthusiasm for multilayer boards because of difficulties in overcoming yield problems. (Yield problems are proportional to the number of layers in the boards). Undoubtedly, the Soviets had considerable reliability problems with the multilayer boards of 25X1 the ES-1050. [redacted] 25X1

The ES-1050 is also unusual when compared with other IBM or Ryad models because it has about three times as many locations for circuit boards as it requires to meet design specifications. This, coupled with the use of ECL circuitry, may indicate that the ES-1050 was merely an intermediate step in the development of an even more powerful computer system [redacted] 25X1

Interim Ryad Models. Little is known about the circuit technology used in the interim Ryad models, but the Soviets probably took advantage of their advances in microelectronics and included monolithic integrated circuits of increased complexity, which made the models increasingly dissimilar to IBM 360 models. The ES-1033, for example, uses 64-bit random 25X1 access memory circuits to build the multiplexer channel storage and protection key storage. Use of these medium-scale integrated components more closely resembles IBM 370-like designs rather than the IBM 360. Use of these components cannot be considered innovative; rather, the Soviets were merely extending the circuit base of their Ryad I designs. [redacted] 25X1

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Ryad II Models. Most of the information on the Ryad II models concerns the ES-1035, ES-1055, and ES-1060 computers. The main memory and channel sections of these computers can provide some indication of how closely the Ryad developers are following IBM 370 developments. The first IBM 370 models, the 155 and 165, used ferrite cores in the main memories. Shortly afterwards, in 1971, the IBM 370s used ICs that enabled IBM to manufacture memories more economically than before and provided increased system performance. The Soviets appear to be following IBM in their first Ryad II models, the ES-1035 and ES-1060. Both are being manufactured initially with ferrite-core memories, and the Soviets have announced an upgraded semiconductor main memory for the ES-1035 and are likely to do so with the ES-1060. The Soviets, however, probably will not have semiconductor main memories for these machines until late 1980. [redacted]

The East German ES-1055 has a main memory based on semiconductor components rather than on ferrite cores. The semiconductor memory components appear to be 1,024-bit random access memory devices implemented in positive channel, metal-oxide semiconductor technology. It is not known whether East Germany is using domestic or Western parts in the manufacture of the ES-1055's main memory, but these parts should be within East Germany's capability to produce. The use of these components probably reflects the relatively advanced position of East Germany among the CEMA countries in microelectronics production. The particular MOS components used by the East Germans, however, do not provide any significant improvement in speed over ferrite-core memory. The failure of the East Germans to push the performance limits of their MOS technology indicates that they opted for a conservative design approach in the ES-1055, which is the first Ryad II computer to use a semiconductor main memory. [redacted]

The conservative approach followed in the main memory of the ES-1055 is also apparent in the logic sections. The ES-1055 microprogram cycle time nearly matches that of its predecessor, the ES-1040, perhaps indicating that the logic in the arithmetic-logic section of the ES-1055 and ES-1040 is similar. Taken together, the logic and memory portions of the ES-1055 suggest that the East Germans were trying to build on the technological base established with the ES-1040 rather than pushing their state of the art to close the gap on the West. The ES-1055 development apparently was focused on providing virtual memory, block multiplexers, and other IBM 370-like features rather than increasing arithmetic speeds. [redacted] 25X1

Software

At the time the Soviets adopted the IBM 360 architecture, they sought to use the extensive software base that IBM and its customers had developed and were maintaining in the field. The Soviets undoubtedly believed that use of IBM software would enable them to overcome many of their past software deficiencies (especially in data-processing applications), save development time, and put their new Ryad hardware into immediate and effective use. On the surface, this plan appears plausible because much of the software information was supplied by IBM and was considered in the public domain. The Soviets are owners of IBM systems legally exported to the USSR and can participate in SHARE, the major IBM user group devoted to the exchange of programs and information. Also, the Soviets had been studying and developing IBM-like system software before the Ryad development was initiated. Judging from the length of time it ultimately took the Soviets to adapt IBM software to their systems, however, it appears that the Soviets underestimated the technical difficulties of such software transfers. Nevertheless, the Soviets succeeded in adapting a significant portion of IBM software for their Ryad systems. [redacted]

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The transfer of software technology can be studied at various levels comprising microprogram, systems, and applications software. These levels form a hierarchy that adapts the computer hardware to specific tasks for an end user. In many respects, the function of the lower level software is essentially transparent to programers working at higher levels. As previously noted, microprogram software is closely related to the circuitry and components and manages the fundamental logical operations in the computer system. The system software is related to the gross architecture and manages the facilities of the computer. The applications software directs the computer to perform certain tasks such as the management of airline reservations or solving hydrodynamics problems. [redacted]

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The Soviets had to develop new microprograms for each of their Ryad I systems. The microcode used on the IBM 360 was designed to execute on a hybrid component base and could not simply be transferred to the Ryad I computers, which are constructed with monolithic ICs. Differences in speeds at which the Ryad components and circuits operate made the IBM microcode practically useless. Some evidence suggests that the Soviets attempted to use the IBM microcode of the early 1960s directly in the development of the ES-1020, which may have resulted in the failures of the initial systems in the early 1970s. [redacted] the first ES-1020 computers that had been delivered to customers required the services of [redacted] software developers [redacted] in rewriting and correcting programs for the channel controllers. This type of difficulty and others forced the Soviets to develop their own microprograms for algorithms that would duplicate the function of the IBM-360 instruction set. [redacted]

The Soviets appear to have been able to use more of the IBM systems software than the IBM microcode. The two major Soviet operating systems, DOS ES (Disc Operating System) and OS ES (Operating System), have all of the major features and capabilities found in the IBM DOS/360 and the more powerful OS/360. This similarity between the basic operating systems of the IBM and ES systems was demonstrated by the fact that an East German ES-1040 successfully ran IBM DOS (level 26) operating system software. The close similarity of other Ryad operating system software to IBM software also is apparent in Soviet literature, which preserves all of the command memonics system messages in English. Use of systems commands written in English may have facilitated development of the Ryad operating systems, but the system has created problems in the effective operation of Ryad systems at some installations. Computer operators, who typically are not as well trained in the English language as software developers, have been forced to use English dictionaries to operate their computer systems. In some cases, the Soviets have progressed beyond using only English in systems programing when they have used English system commands with Russian data set names written in Cyrillic [redacted]

Despite the close similarity of Ryad I operating systems to IBM software, Western experts have judged that the Soviets and their CEMA partners took approximately the same amount of time to duplicate the IBM operating systems software as it took IBM to develop it originally. Undoubtedly, the Soviets ran into innumerable small, correctable problems related to hardware differences between Ryad and IBM. In addition, the Soviets faced a tremendous morale problem in motivating young programers to perform the very tedious and seemingly uncreative work of translating IBM software and related documentation 25X1
into the Ryad framework. Lastly, skills and techniques 25X1
in software systems integration and testing are not easily acquired from literature evaluation. Inexperi- 25X1
ence in these areas probably hampered Soviet assimila- 25X1
tion of IBM software [redacted] 25X1

The USSR revealed a thorough study and at least a surface comprehension of IBM 360 software only a year or two after the software was first delivered to 25X1
IBM customers. For example, the Soviet Ministry of Instrument Building, Automation Equipment, and Control Systems had major investments in adapting IBM 360 software to its ASVT computer project by 1968 and before the decision was finalized to use the IBM 360 architecture in the Ryad project under the leadership of the Ministry of the Radio Industry. Apparently, more development beyond this earlier work was needed to adapt and assimilate IBM software, particularly system software, in sufficient depth to support the Ryad project. Citations in the Soviet software literature indicate that the analysis of IBM DOS/360 under the leadership of M. R. Shura-Bura had a significant role in Soviet development of system software for Ryad. Shura-Bura's work may have been the result of a crash effort in response to software problems that remained even after substantial numbers of Ryad computers were delivered to customers [redacted] 25X1

The Soviets and their CEMA partners probably are attempting to gain full compatibility between the Ryad II and IBM 370 system software. The Czechoslovaks at the Research Institute for Mathematical Machines, for example, are using an IBM-370/125 as

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a test bed for their new DOS-3 operating system for the ES-1025; this system is similar to the IBM DOS/VS. The Soviets at Minsk have developed a DOS-2 operating system for their interim Ryad and Ryad II models that includes an emulator for the popular Minsk-32, which enables software for the Minsk-32 to be executed on the Ryad Systems. Thus, this operating system will enable the Soviets to bring the many users into the Ryad software picture and ease the transition from older to newer computer hardware. [redacted]

The East Germans are perhaps the furthest along with their development of OS ES Version 6.0, which contains software for virtual memory and many other IBM 370 features. The Soviets do not appear as advanced as the East Germans; their Ryad II systems that were being shipped in late 1979 to operate under DOS or OS ES 4.0 do not contain virtual memory features. The Soviets have attempted unsuccessfully to short cut some of the software development for their Ryad II systems by trying to acquire a blanket license for IBM virtual system software. Evidently, they believed that their Ryad II hardware is close enough to the IBM 370 to permit such a deal. [redacted]

While the Soviets have succeeded in translating IBM system software into Ryad system software, they have not included any significant upgrades or modifications to the IBM software. Furthermore, they have not been successful in undertaking large software systems developments, at least in the civil sector. In part this is probably due to the limited cadre of competent systems programers who are needed for priority developments as well as a lack of deep appreciation of why IBM operating systems are structured the way they are. [redacted]

In the applications software area, the Soviets have not been faced with problems in acquiring Western software. A tremendous amount of Western software is available, can be duplicated readily, and has been aggressively acquired by the Soviets both in connection with hardware sales and in formal and informal Western contacts, such as during the US-USSR bilateral agreement meetings and with US corporations. An increasing amount of applications software is being written in higher level languages such as FORTRAN, COBOL, and PL-1, which are more readily transferred from system to system than assembler language programs. The Soviets, however, have been slow to make effective use of all the software that has been available. They have been slow to provide the adequate documentation, the proper maintenance, and the user-developer interface at which IBM excels. [redacted] 25X1

The Soviets also have had problems in the development of large applications packages, which have been 25X1 developed in the West. The Soviets do not appear to be applying the expertise that they could have gained from training and using large Western software systems acquired for Intourist and Aeroflot. Undoubtedly, the Soviets have been hampered to some extent by their lack of experience in software design, systems integration, testing, and meeting user demands. The large amount of rather mundane coding and programing required also must be contrary to Soviet predilection towards mathematical and theoretical research. The Soviets are beginning to recognize the importance of such work, and the award of USSR State Prize in 1979 to systems software developers is indicative of high-level interest in software development. This was 25X1 the first time the award was given to software specialists. [redacted] 25X1

In the future, the Soviets and East Europeans will attempt to train increasing numbers of software specialists and vigorously pursue Western techniques in effective management of large software projects. Since such knowledge must come from experience, the Soviets will benefit from exchange agreements in which they learn how to organize software development, from personal contacts, and from training provided by the West. In addition, as more and more of 25X1 the IBM operating system software vanishes into proprietary microcode, the Soviets and East Europeans can be expected to target clandestine acquisition against IBM itself in order to maintain compatibility.

[redacted] 25X1

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